Appendix E
REGIONAL MODELING FOR THE LOWER EAST COAST REGIONAL WATER SUPPLY PLAN

GENERAL DESCRIPTION

Model Used (SFWMM v3.7)

The complex water management system in South Florida is influenced by a unique hydrology, an intricate water control infrastructure and a comprehensive set of operational policies. South Florida is unique due to its flat topography, high water table, sandy soils, and highly transmissive surficial aquifer. There are over 1,400 miles of levees and canals, 18 major pump stations, and more than 180 control structures in South Florida. The South Florida Water Management District (District, SFWMD), in collaboration with several federal, state, and local agencies, is assigned the task of evaluating several environmental and water resource development projects within the next two decades that will enable the present and future urban, agriculture, and natural system water needs to be met within the Lower East Coast (LEC) Planning Area.

A critical component of the LEC planning effort is computer modeling. It provides a feasible means of assessing systemwide impacts of the various proposed modifications to the water resources system in South Florida without the time delay and capital expense of field testing individual projects. The South Florida Water Management Model (SFWMM v3.7) is the model used by the SFWMD to simulate alternatives for the LEC water supply planning process.

The SFWMM is an integrated surface water-ground water model that simulates the hydrology and associated water management schemes in the majority of South Florida using climatic data from January 1, 1965, through December 31, 1995. The model simulates the major components of the hydrologic cycle that includes rainfall, evapotranspiration (ET), infiltration, overland and ground water flow, canal flow, and levee seepage. The model also simulates current and numerous proposed water management control structures and associated operating rules. A key management feature of the model is its ability to simulate different water shortage policies, current and proposed, for the different subregions in the system (e.g., LEC water shortage and Lake Okeechobee Service Area supply-side management plans). The gridded portion of the model domain employs a distributed modeling approach. Lake Okeechobee is simulated as a lumped hydrologic system. The amount, timing, and distribution of structure flows in and out of the lake are dictated by management rules related to flood control, water supply, and environmental restoration. Also, the model simulates inflows from Kissimmee Basin, and runoff and managed discharges within the St. Lucie and Caloosahatchee Basins.

Documentation

The most recent published documentation of the model is *A Primer to the South Florida Water Management Model (Version 3.5)* (SFWMD, 1999). This publication was completed in partial support of the computer modeling efforts for the Central and Southern Florida Project Comprehensive Review Study (Restudy) which was completed in

(USACE and SFWMD, 1999). The documentation is available on-line at http://www.sfwmd.gov/org/pld/hsm/models/sfwmm.

Temporal and Spatial Scale

A fixed time step of one day is used in the model. The selection of this time step is consistent with the minimum time increment for which hydrologic data such as rainfall, evaporation, and structure discharge are generally available. Rainfall and potential evaporation (PET) are the primary driving processes. Therefore, the longest total simulation time for the model is a function of the available historical (or an estimate of historical) rainfall and PET data. The model (version 3.2 and later) can be run for as short as one month and for as long as 31 years from January 1, 1965, through December 31, 1995. The hydrologic processes are generally modeled sequentially within one time step. A continuous unconfined ground water system is assumed to underlie the gridded portion of the model domain. To simplify programming and reduce computational time, no iteration is performed between surface and ground water routines within a time step., Within a time step, calculations for more transient phenomena, such as channel flow routing, are performed before less transient phenomena, such as ground water flow. The bulk of the computer code is comprised of the operational rules that drive the human management of the entire system.

The gridded portion of the model domain describes the extent of the finite difference solution to the governing overland and ground water flow equations and is defined just south of Lake Okeechobee (**Figure E-1**). The network is comprised of two-mile square grid cells that cover the large coastal urban areas of Palm Beach, Broward, and Miami-Dade counties, the Everglades Agricultural Area (EAA); the Water Conservation Areas (WCAs), and Everglades National Park. The model has 1,746 computational grid cells. The SFWMM assumes homogeneity in physical, as well as hydrologic characteristics within each grid cell. In addition to water levels at grid cells, and surface and ground water flow between cells, the model also calculates discharges for the major hydraulic structures within the model domain.

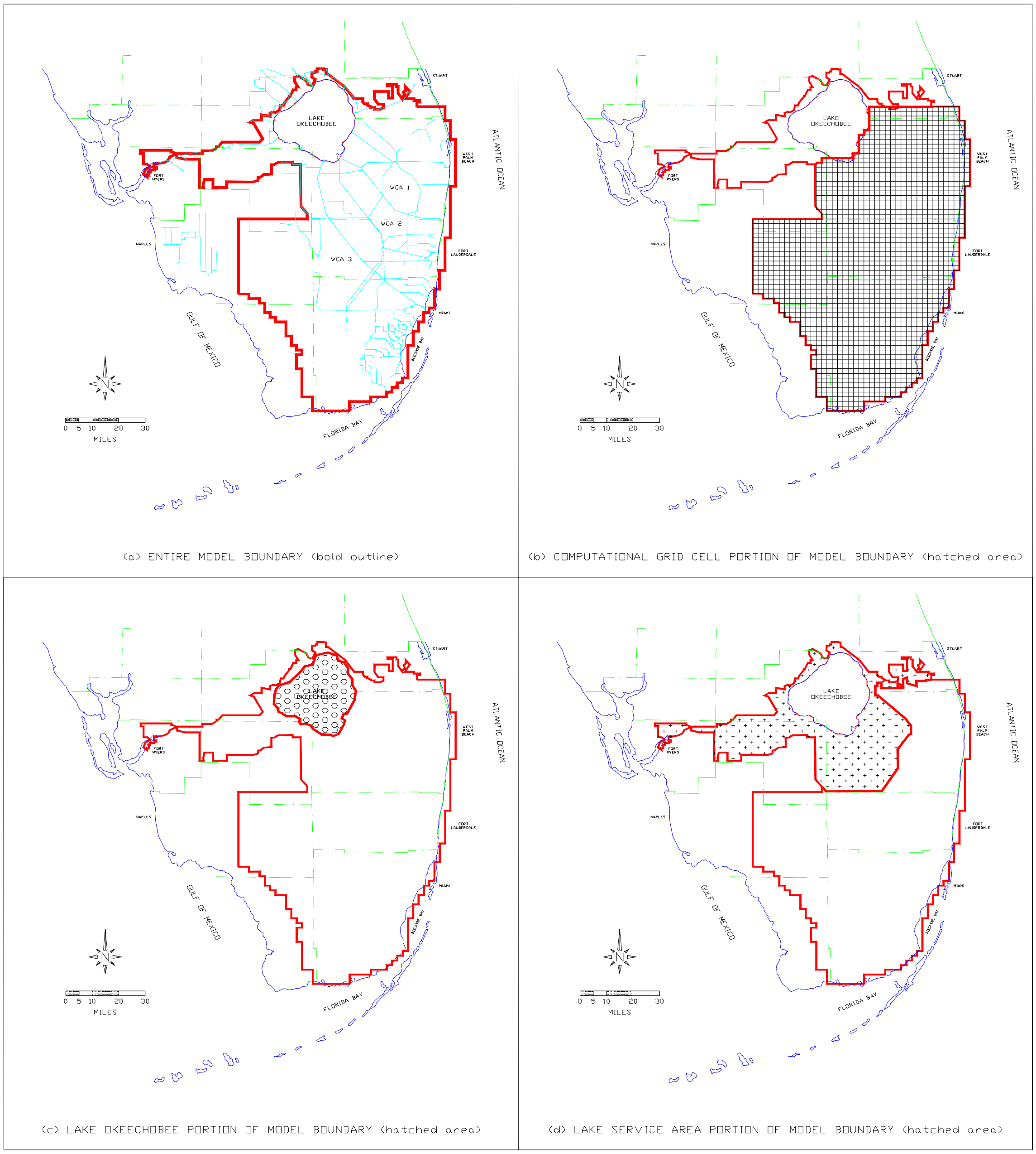


Figure E-1. South Florida Water Management Model Boundaries.

Rainfall and Evapotranspiration

Rainfall is the main climatic data that the SFWMM uses to simulate daily hydrology from Lake Okeechobee to the southern tip of the Florida peninsula. The model uses a spatial database, based on almost 700 rainfall stations, to assign a rainfall value for each model grid cell on a daily basis. A nearest station approach was used in the model in lieu of a more rigorous method. While this approach may not yield the best estimate of rainfall, it affords several advantages over different interpolation/estimation methods:

- With a fairly large set of raw data, as in the case of the SFWMM, no estimation of missing rainfall data is required. Although rainfall is a continuous variable, a value of zero is not uncommon.
- Most interpolation methods tend to assign nonzero values for days when no recording is made. The method employed in both models uses the next best estimate of the rainfall by using the closest available rainfall station.
- The current estimation method is flexible enough to accept updated information and additional rainfall stations as they become available.

The calculation of ET in the SFWMM is based on reference crop ET which is adjusted according to crop type, available soil moisture content, and location of the water table. Algorithms used to calculate actual ET vary geographically because of different data availability, calibration approaches, and varying physical and operational characteristics of different areas within the model domain. For Lake Okeechobee, the pan evaporation method is used to calculate open water and marsh zone ET. In the EAA, total ET is the sum of its components from the saturated, unsaturated, and open water zones. In nonirrigated areas, such as the Everglades, the unsaturated zone does not exist and total ET is calculated as the sum of open water evaporation and saturated zone (water table) ET. Finally, in irrigated areas within the LEC Planning Area, a simple accounting procedure is used to calculate unsaturated zone ET while saturated and open water ET are calculated based on the Penman-Monteith (P-M) reference crop ET.

In all cases, the generalized form of the ET function in the model is **Equation E-1**. A reference crop ET is computed for each of the ten data collection sites using meteorological data such as rainfall, temperature, sky cover, and wind speed.

$$ET = K \times E_0 \qquad \textit{E-1}$$

where:

K = an adjustment factor that takes into account vegetation/crop type and location of the water table relative to land surface

E_0 = the Penman-Monteith reference crop (turf grass) ET

The actual reference ET assigned to each grid cell is obtained from a linear interpolation scheme based on the grid cell's inverse distance from all ten stations. The P-M equation (Monteith, 1965), in its original form, is given by **Equation E-2**.

$$\lambda ET_0 = \frac{\Delta(R_n - G) + \rho C_p (e_a - e_d)\frac{1}{r_a}}{\Delta + \gamma\left(1 + \frac{r_c}{r_a}\right)} \qquad E\text{-}2$$

where:

λET_0 = latent heat flux of evaporation (KJ m^{-2} s^{-1})

ET_0 = mass flux of ET (kg m^{-2} s^{-1})

λ = latent heat of vaporization (KJ kg^{-1})

Δ = slope of vapor pressure curve (kPa $^oC^{-1}$)

R_n = net radiation flux at surface (KJ m^{-2} s^{-1})

G = soil heat flux (KJ m^{-2} s^{-1})

ρ = atmospheric density (kg m^{-3})

C_p = specific heat of moist air (KJ kg^{-1} $^oC^{-1}$)

e_a = saturation vapor pressure at surface temperature (kPa)

e_d = actual ambient vapor pressure at dew point (kPa)

$(e_a - e_d)$ = vapor pressure deficit (kPa)

γ = psychrometric constant (kPa $^oC^{-1}$)

r_c = crop canopy resistance (s m^{-1})

r_a = aerodynamic resistance (s m^{-1})

Overland Flow

The diffusion flow model (Akan and Yeh, 1981) is used to simulate overland flow in the SFWMM. The primary driving force for diffusion flow is the slope of the water surface. A diffusion wave model accounts for backwater effects but prohibits water from traveling opposite head gradients. Essentially the continuity and momentum equations are solved. The two-dimensional continuity equation for shallow water flow is **Equation E-3**.

$$\frac{\partial h}{\partial t} + \frac{\partial(hu)}{\partial x} + \frac{\partial(hv)}{\partial y} - q = 0 \qquad E\text{-}3$$

where:

h = water depth (ft)

u, v = velocity in the x- and y- directions (ft/day)

q = vertical influx which consists of the net effect of rainfall, infiltration, and ET (ft/day)

t = time (day)

x and y = Cartesian coordinates aligned along the major axes of hydraulic conductivity or transmissivity

Expressing depth of flow as water level above a datum, the momentum equation in the x-direction can be expressed as **Equation E-4**, while the momentum equation in the y-direction is **Equation E-5**.

$$\frac{\partial H}{\partial x} + \frac{\tau_{bx}}{\rho g h} = 0 \qquad \textit{E-4}$$

$$\frac{\partial H}{\partial y} + \frac{\tau_{by}}{\rho g h} = 0 \qquad \textit{E-5}$$

where:

H = h + z

h + z = water level above a given datum (ft NGVD); the SFWMM uses the National Geodetic Vertical Datum (NGVD) of 1929

h = depth of flow (ft); the hydraulic radius is essentially the depth of flow for wide channels

z = channel bottom elevation above the datum (ft NGVD)

τ_{bx}, τ_{by} = bed (bottom and sides) shear stress in the x- and y- directions (lb/ft^2)

ρ = density of water ($slugs/ft^3$)

g = acceleration due to gravity (ft/sec^2)

After some mathematical manipulations, the solution to the governing equations yields an expression for the cell-to-cell flow velocities in the x- and y- directions (SFWMD, 1999). These are given as **E-6** and **E-7**. Using a finite difference representation of these equations, an alternating direction explicit (ADE) scheme is used to solve the governing equations within the model.

$$u = 1.49\frac{h^{\frac{2}{3}}}{n\sqrt{S_n}}\frac{\partial H}{\partial x} \qquad E\text{-}6$$

$$v = 1.49\frac{h^{\frac{2}{3}}}{n\sqrt{S_n}}\frac{\partial H}{\partial y} \qquad E\text{-}7$$

where:

n = the overland flow roughness coefficient which varies as a function of depth of flow

S_n = the maximum energy slope

Ground Water Flow

Ground water flow in the SFWMM involves the solution to the Partial Differential Equation (PDE) describing transient flow in a two-dimensional, anisotropic, heterogeneous, unconfined aquifer. The PDE is of the form of **Equation E-8**:

$$\frac{\partial}{\partial x}\left(T_{xx}\frac{\partial h}{\partial x}\right) + \frac{\partial}{\partial y}\left(T_{yy}\frac{\partial h}{\partial y}\right) = S\frac{\partial h}{\partial t} - R \qquad E\text{-}8$$

where:

T_{xx} and T_{yy} = transmissivity tensors of the aquifer (ft^2 /day)

h = the unknown hydraulic or potentiometric head (ft)

S = unconfined aquifer storage coefficient or specific yield of the porous media; vertically-averaged specific storage; volume of water released or taken into storage per unit cross-sectional area per unit change in hydraulic head in the aquifer (dimensionless)

R = recharge; volumetric flux per unit surface area (ft/day)

A finite difference scheme using a modified Saul'yev (1964) method is used to solve the above equation. This procedure is unconditionally stable and explicit. The scheme uses a finite difference formulation that varies in four different directions that is solved in four successive time steps.

Infiltration and Percolation

Infiltration is the process by which water on the soil surface enters the soil column. Water may come from rainfall and/or irrigation and increases moisture in the unsaturated zone or directly goes to the saturated zone via percolation. Percolation is the recharge to the saturated zone or the amount of water crossing the water table. In South Florida, where unconfined aquifer conditions exist, the location of the water table determines the upper limit of the saturated zone. Ponding exists when the water table elevation exceeds the land surface elevation and the unsaturated zone no longer exists. Infiltration and percolation are assumed to be strictly vertical processes. The volume of infiltration is taken as the minimum of the following three quantities:

- Available water (above land surface) to infiltrate
- Infiltration rate multiplied by grid cell area and time step
- Available void space between the water table and land surface

Infiltration rates vary from grid cell to grid cell and were determined from the soil classification scheme used for the entire model domain. Percolation is the amount of water that enters the saturated zone when field capacity is exceeded. Field capacity is the maximum moisture content that can be stored in the unsaturated zone.

Levee Seepage

To facilitate urban development in the LEC Planning Area, drainage canals were constructed to lower the water table and drain surface water from the eastern portion of the Everglades to the Atlantic Ocean. To protect the developing urban sprawl from the Everglades flood waters, an extensive east coast protective levee system was built in the 1950s and early 1960s as part of the federally funded Central and South Florida Project for Flood Control and Other Purposes (C&SF Project). Hydrologically, these levees resulted in highly concentrated easterly ground water flows, most of which are diverted south via a system of borrow canals just east of the levees. Unfortunately, levee seepage cannot be adequately simulated by a coarse model such as the SFWMM. Therefore, a set of regression equations were derived to empirically represent levee seepage within the SFWMM. These equations were based on an independent set of computer simulation runs using SEEPN. SEEPN is a two-dimensional (vertical plane) finite element model developed at the U.S. Army Corps of Engineers Waterways Experiment Station (USGS-WES). This latter model simulates steady state subsurface flow through a multilayered aquifer system by solving the Laplace equation using Darcy’s Law (Tracy, 1983).

In the SFWMM, the total subsurface flow beneath a levee is the sum of the regional ground water flow (underseepage) and levee seepage (**Figure E-2**).

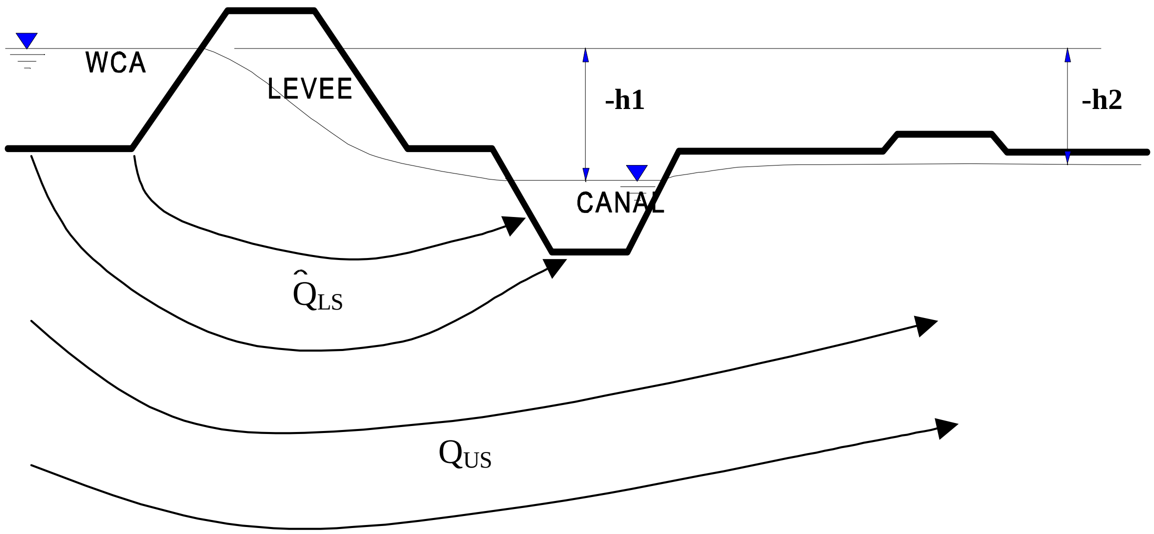


Figure E-2. Canal-Levee configuration depicting levee seepage (Q_{LS}) and underseepage (Q_{US}) as simulated in the South Florida Water Management Model.

The regression equation is of the form of **Equation E-9**:

$$Q_{seep} = \beta_0 + \beta_1 \Delta h_1 + \beta_2 \Delta h_2 \qquad \textit{E-9}$$

where:

Q_{Seep} = the levee seepage in cubic feet per second/mile

β_0, β_1, β_2 = levee seepage coefficients

Δh_1 = the head gradient across a levee representing the difference in the water levels inside a WCA and a levee borrow canal (local head gradient)

Δh_2 = the head gradient across a levee representing the difference in the water levels on opposite sides of a levee borrow canal (regional head gradient)

Canal and Structures Flow

Canal or channel flow routing in the SFWMM uses a mass balance approach to account for any changes in storage within a canal reach given beginning-of-day canal stage, canal and structure properties, and calculated or specified inflows and outflows. The mass balance is performed every time step for each canal reach and involves grid cells where each canal reach passes through. The SFWMM assumes that the width of a canal is constant along its entire length. The model also assumes a wedge-shaped longitudinal water level profile such that a seasonal offset or head drop occurs along the length of each canal reach. This offset can be considered as a predefined slope in the hydraulic grade line that represents the average or long-term difference between the stage in the canal at its upstream end and at its downstream end. It is assumed to vary seasonally and is independent of the discharge in the channel. This simplification is used to trace flow and stages within the canal as a function of space and time, unlike traditional distributed flow routing procedures, i.e., solution of the kinematic, diffusion, or dynamic wave equations. The components of the canal water budget are rainfall, ET, overland flow, canal seepage, and structure inflows and outflows. Because some of these components are functions of canal stage, an iterative procedure is used to calculate the end-of-day canal stage.

A complex set of inflow and outflow rules is used in the model by all structures (weirs, spillways, pumps, and culverts) along the length of each canal. Several other structure operating rules are coded in the model that govern flow in and out of storage areas (e.g. lakes, reservoirs, Stormwater Treatment Areas [STAs], and WCAs) (SFWMD, 1999).

In the LEC service areas (LECSAs), reservoirs are generally proposed as part of the Water Preserve Areas whose functions are 1) to store excess water from a drainage basin which may result in increased flood control in the basin and reduced seepage volumes from the WCAs and 2) to release the stored water for water supply purposes and/or environmental enhancement to decrease the dependence of the LECSAs on the regional system. Aquifer Storage and Recovery (ASR) wells are proposed in conjunction with reservoirs to enhance the system's ability to store water and to effectively use excess water during times of need.

Surface-Subsurface Interaction

One of the strengths of the SFWMM is its ability to simultaneously describe the state of the surface water and ground water systems within the model domain. This state is defined in terms of ponding depths, unsaturated zone water content, and ground water levels. Recharge, levee seepage, and the procedures briefly outlined in the preceding discussions comprise the vertical coupling of ground water and surface water in the model. Recharge is the combined effect of percolation, ET, canal-ground water seepage, and aquifer withdrawal for domestic, industrial, and irrigation purposes.

Figure E-3 shows a block diagram of the physical processes simulated in the model for surface and subsurface systems. Rainfall is a process that moves water from the atmosphere into surface storage. ET is the movement of water from both surface and subsurface systems into the atmosphere. A canal, which is essentially a special form of surface storage, exchanges water with ponding and the saturated zone storage through runoff/overbank flow and canal-ground water seepage, respectively. Lastly, levee seepage is a localized flow phenomenon that describes the movement of water from the aquifer across a major levee and into a borrow canal.

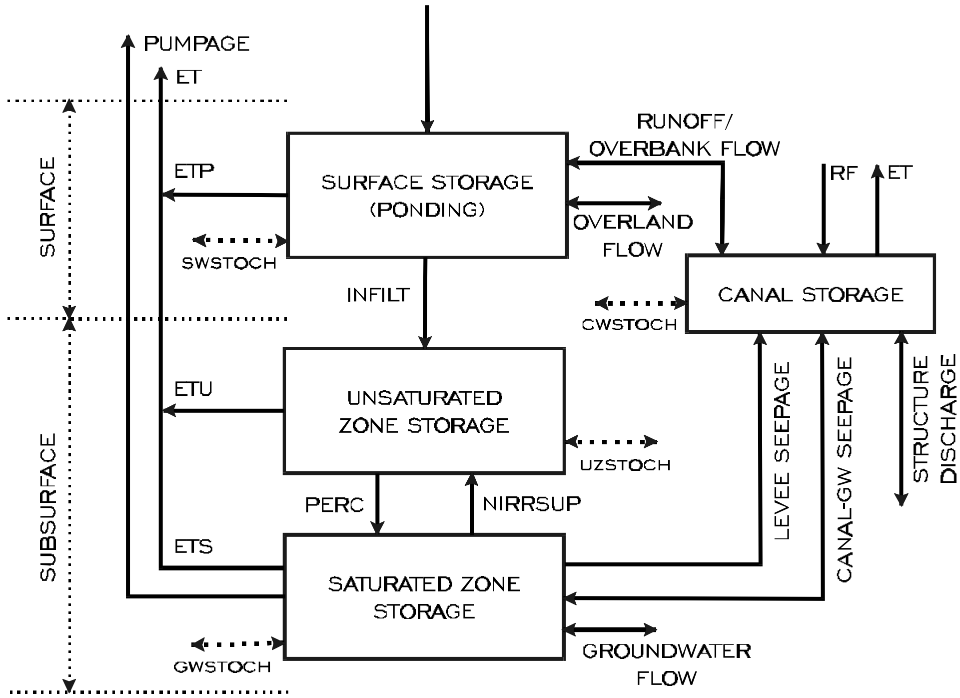


Figure E-3. Generalized Block Diagram of Surface-Subsurface Interaction in the South Florida Water Management Model.

Accuracy

In order to demonstrate model accuracy, water budget postprocessing tools are available to summarize water budget components on a monthly, seasonal, and annual basis for individual or group of grid cells. Also, calibration exercises are routinely performed on the model to demonstrate history-matching capabilities of the model (SFWMD, 1999).

Several publications and presentations have been made in the past to address model accuracy and model applicability (e.g., Lal, 1998; Bales et al., 1997; Loucks et al., 1998).

Previous Applications of SFWMM

The SFWMM has been the primary modeling tool for evaluating regional-scale effects of major water management projects associated with the Lake Okeechobee-Everglades system. The model has been used for the following projects:

- Development of the *Draft Lower East Coast Regional Water Supply Plan* (SFWMD, 1993)
- *Central and Southern Florida Flood Control Project Comprehensive Review Study Final Integrated Feasibility Report and Programmatic*

Environmental Impact Statement (Restudy) (USACE and SFWMD, 1999)

- *Development of Regulation Schedules for Lake Okeechobee* (SFWMD and USACE, 1999)
- Several studies related to the hydrologic restoration of the Everglades

The SFWMM is an appropriate tool for evaluating large-scale, long-term hydrologic effects from structural and operational modifications. Since the model has a coarse (two mile-by-two mile square grid cells) and a daily time step, it cannot adequately evaluate local-scale or highly transient events (e.g. flooding in individual farms and local developments). However, the model's utility can be extended beyond these limitations. Model output is being used as boundary conditions for the more detailed countywide ground water models (http://www.sfwmd.gov/org/pld/proj/lec/aboutmod.html). Likewise, since the SFWMM is essentially a water transport model, its output has been used as input to water quality models (http://www2.shore.net/~wwwalker/restudy) and some ecological models (http://www.sfwmd.gov/org/pld/restudy/hpm)

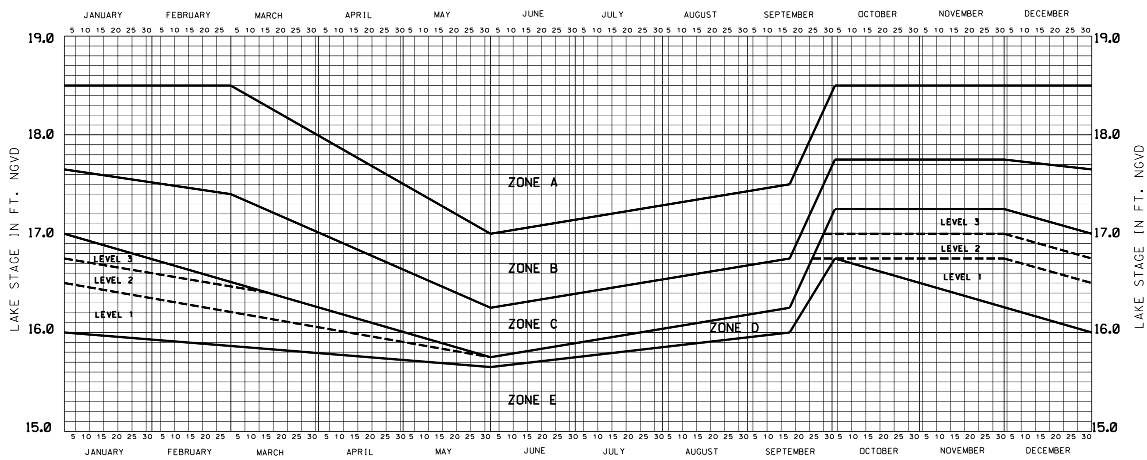
SPECIFIC ASSUMPTIONS AND ROUTINES DEVELOPED FOR SOUTH FLORIDA WATER MANAGEMENT MODEL VERSION 3.7

LEC alternatives were designed to address local needs and formulated to be more responsive to local and state mandates, based on knowledge gained from the SFWMM simulations for the Restudy, the Modified Water Delivery Project, and the Everglades Construction Project. Thus, a few modifications in the modeling assumptions and enhancements were incorporated into the model. Although most of these changes focus on areas outside the LECSAs, they may impact or enhance the effectiveness of the components of the proposed alternatives specific to the LEC Planning Area. Specifics on these changes and their impact on the different base run scenarios can be found in Santee (1999).

Water Supply and Environmental Schedule for Lake Okeechobee

Water levels in Lake Okeechobee are currently managed through regulatory (flood control) and nonregulatory releases. Regulatory releases are made according to a regulation schedule, established by the USACE in conjunction with the District and other public entities, to ensure that the integrity of the peripheral levee is not compromised due to high water levels. The regulatory level for Lake Okeechobee ranges from 15.65 ft NGVD in late May to 16.75 ft NGVD on October 1. The summary of the regulatory rules, the Run 25 Schedule, as set forth by the USACE is given in **Figure E-4**.

Nonregulatory releases are made to meet (1) water supply requirements of the LECSAs, (2) agricultural/irrigation demands in the Lake Okeechobee Service Area (LOSA), and (3) environmental needs of the St. Lucie and Caloosahatchee estuaries, the



RELEASE THROUGH OUTLETS AS INDICATED

ZONE	AGRICULTURAL CANALS (2)	CALOOSAHATCHEE RIVER (2)	ST. LUCIE CANAL
A	PUMP MAXIMUM PRACTICABLE TO WCA'S	UP TO MAXIMUM CAPACITY AT S-77	UP TO MAXIMUM CAPACITY AT S-80
B (1)	MAXIMUM PRACTICABLE TO WCA'S	6500 CFS AT S-77	3500 CFS AT S-80 (3)
C (1)	MAXIMUM PRACTICABLE TO WCA'S	UP TO 4500 CFS AT S-77	UP TO 2500 CFS AT S-80 (3)
D	MAXIMUM PRACTICABLE TO WCA'S	MAXIMUM NON-HARMFUL DISCHARGES TO ESTUARY WHEN STAGE RISING	MAXIMUM NON-HARMFUL DISCHARGES TO ESTUARY WHEN STAGE RISING (3)
E	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE

NOTES: (1) RELEASES THROUGH VARIOUS OUTLETS MAY BE MODIFIED TO MINIMIZE DAMAGES OR OBTAIN ADDITIONAL BENEFITS.
(2) SUBJECT TO FIRST REMOVAL OF LOCAL RUNOFF.
(3) EXCEPT WHEN EXCEEDED BY LOCAL INFLOW.

CENTRAL AND SOUTHERN FLORIDA
INTERIM REGULATION SCHEDULE
LAKE OKEECHOBEE
DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA
DATED: 27 DEC 1994

RUN 25

Figure E-4. The Run 25 Schedule for Lake Okeechobee.

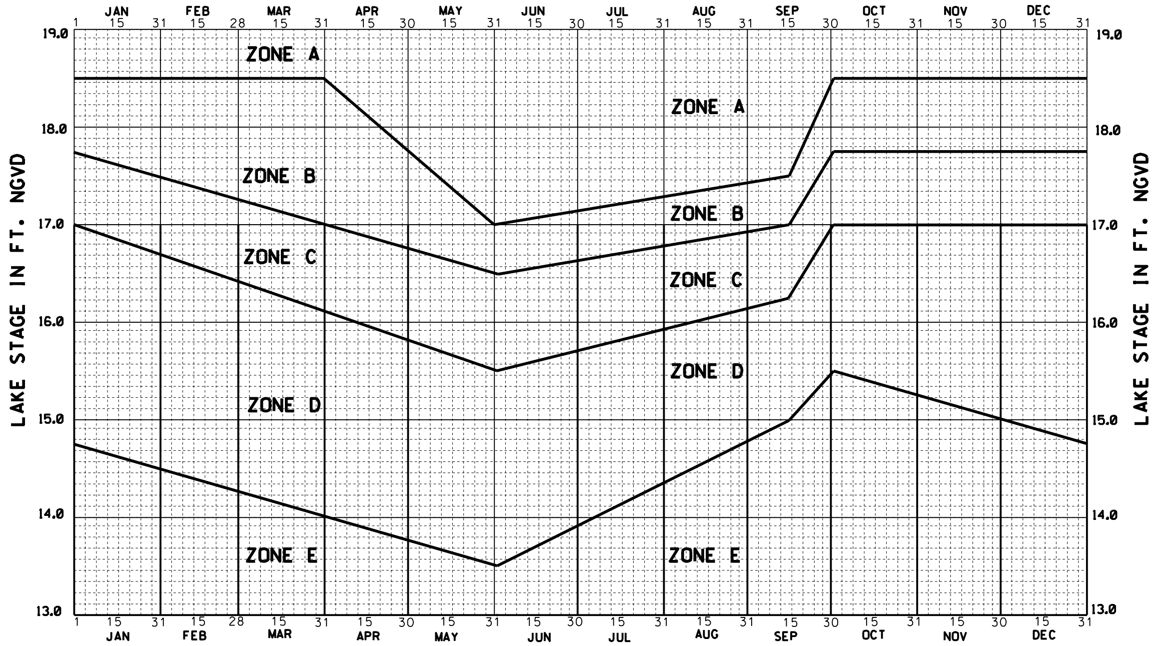
WCAs, and Everglades National Park. These releases are sent to areas in the system that may need water for irrigation (e.g., EAA), saltwater intrusion control (e.g., canals), domestic use (e.g., some lakeside communities), backup water supply (e.g., LECSAs), and environmental enhancement (e.g., estuaries and WCAs). Currently, no detailed and comprehensive policy governs lake environmental release. The model, however, has the capability to make this type of lake releases based on meeting stage and flow targets (minimum flows and levels), and in conjunction with other proposed infrastructures in the system such as STAs, ASR technology, and impoundments like reservoirs or buffer (marsh) areas.

The regional simulation models used in the LEC water supply planning process included an operational assumption of supplying sufficient water to the STAs to avoid dry-out, a condition that would compromise the performance of phosphorus removal. In accordance with a prioritization scheme in the simulations, water is delivered from Lake Okeechobee to maintain a minimum level of six inches is in the STAs. Prioritization of Lake Okeechobee water is first to the LOSA and then to the STAs to meet the six-inch minimum maintenance level. Thereafter, water is supplied to meet LEC Planning Area water supply demands or to meet environmental demands in the WCAs through the STAs.

When Lake Okeechobee goes into Supply-Side Management cutbacks, water is still supplied to the STAs for their six-inch minimum level requirement. When the lake drops into Zone B of the Supply-Side Management schedule, flow from the lake to the STAs to maintain the six-inch minimum is cut off completely, even though there may still be some reduced flows to LOSA to meet demands there.

Full implementation of the proposed Water Supply and Environmental (WSE) Operational Schedule (**Figure E-5**) is now part of the most recent version of SFWMM. Emphasis was placed on water supply and environmental objectives (within the lake and affected areas) in the development of the WSE schedule with some increase in the lake's flood protection capability. A highly desirable approach in overall Lake Okeechobee management is to consider the entire spectrum of hydrologic, meteorologic, and climatic data and forecasts when implementing the WSE schedule. In order to achieve operational proficiency, the schedule incorporates tributary hydrologic conditions and climate forecasts.

Figure E-6 shows a detailed operational decision tree that will enable the successful implementation of the WSE schedule. Due to the approximate nature of extended climate forecasts, the extent of their application is proposed to be constrained by hydrologic conditions existing within the vast tributary basins (SFWMD and USACE, 1999).



RELEASE THROUGH OUTLETS AS INDICATED

ZONE	AGRICULTURAL CANALS To WCAs (1,2)	CALOOSAHATCHEE RIVER AT S-77 (1,2,4)	ST. LUCIE CANAL AT S-80 (1,2,4)
A	PUMP MAXIMUM PRACTICABLE	UP TO MAXIMUM CAPACITY	UP TO MAXIMUM CAPACITY
B (3)	MAXIMUM PRACTICABLE RELEASES	NORMAL TO WET: UP TO 6500 CFS DRY: UP TO MAXIMUM PULSE RELEASE	NORMAL TO WET: UP TO 3500 CFS DRY: UP TO MAXIMUM PULSE RELEASE
C (3)	MAXIMUM PRACTICABLE RELEASES	WET: UP TO 4500 CFS NORMAL: UP TO MAXIMUM PULSE RELEASE DRY: NONE	WET: UP TO 2500 CFS NORMAL: UP TO MAXIMUM PULSE RELEASE DRY: NONE
D (3,5)	AS NEEDED TO MINIMIZE ADVERSE IMPACTS TO THE LITTORAL ZONE WHILE NOT ADVERSELY IMPACTING THE EVERGLADES. (SEE NOTE 5.)	VERY WET: UP TO MAXIMUM PULSE RELEASE OTHERWISE: NONE	VERY WET: UP TO MAXIMUM PULSE RELEASE OTHERWISE: NONE
E	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE

NOTES: (1) SUBJECT TO FIRST REMOVAL OF RUNOFF FROM DOWNSTREAM BASINS
(2) GUIDELINES FOR WET, DRY AND NORMAL CONDITIONS ARE BASED ON: 1) SELECTED CLIMATIC INDICES AND TROPICAL FORECASTS AND 2) PROJECTED INFLOW CONDITIONS. RELEASES ARE SUBJECT TO THE GUIDELINES IN THE WSE OPERATIONAL DECISION TREE, PARTS 1 AND 2.
(3) RELEASES THROUGH VARIOUS OUTLETS MAY BE MODIFIED TO MINIMIZE DAMAGES OR OBTAIN ADDITIONAL BENEFITS. CONSULTATION WITH EVERGLADES AND ESTUARINE BIOLOGISTS IS ENCOURAGED TO MINIMIZE ADVERSE EFFECTS TO DOWNSTREAM ECOSYSTEMS.
(4) PULSE RELEASES ARE MADE TO MINIMIZE ADVERSE IMPACTS TO THE ESTUARIES
(5) ONLY WHEN THE WCAs ARE BELOW THEIR RESPECTIVE SCHEDULES

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INTERIM REGULATION SCHEDULE
LAKE OKEECHOBEE

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DATED: 5 NOVEMBER 1999

WSE (WITH CLIMATE OUTLOOK)

Figure E-5. The WSE Schedule for Lake Okeechobee.

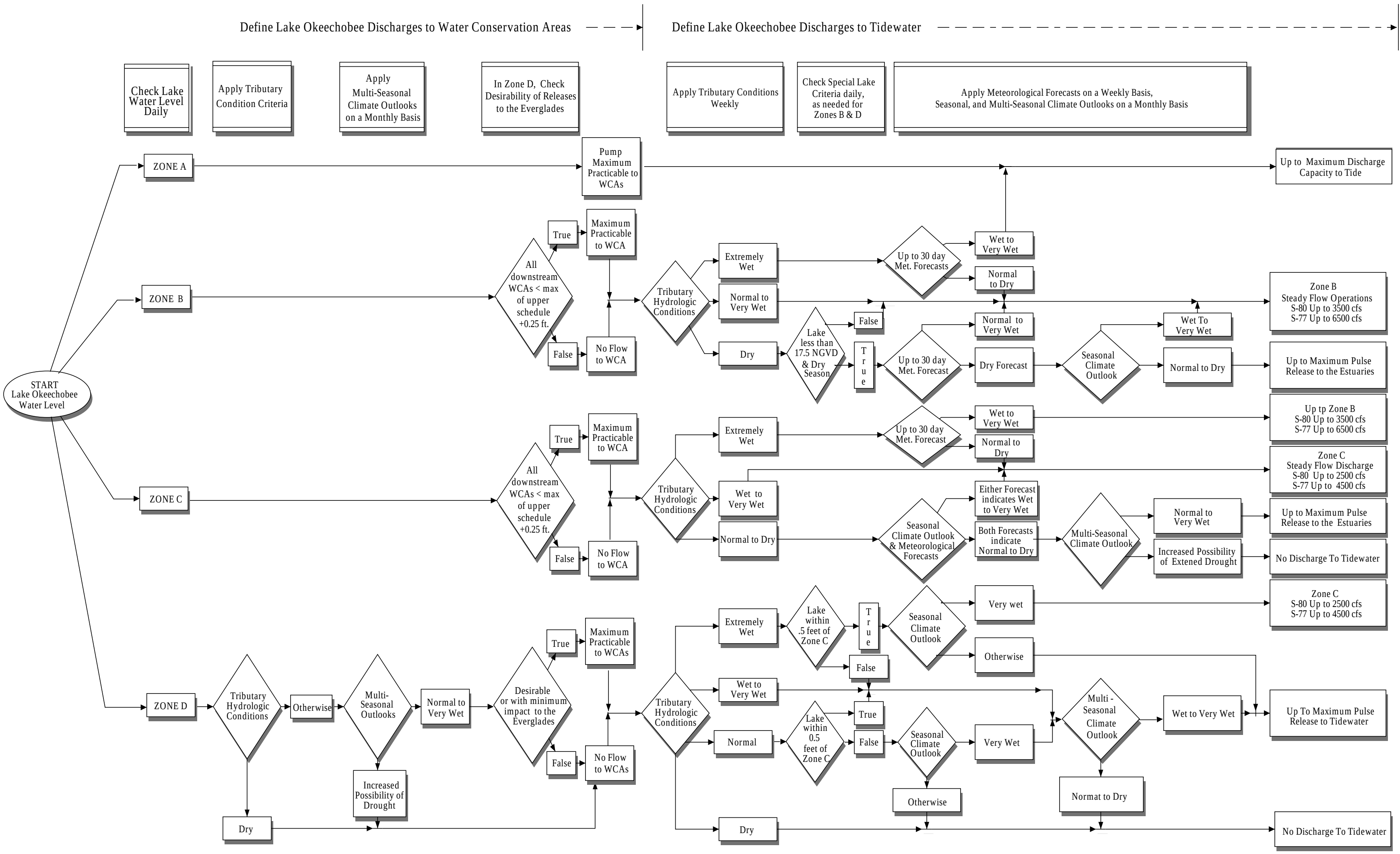

Figure E-6. WSE Operational Decision Tree.

Optimized Aquifer Storage and Recovery Operations

ASR is a water management technology in which water is stored under ground in a suitable aquifer through a well during times when the water is available and recovered from the same well when needed (Pyne et al., 1996). The SFWMM simulates ASRs by performing a simple water budget on the mound of injected water below the surficial aquifer, taking into consideration inefficiencies in injection and withdrawal phases of the operation. ASRs do not lose water via ET which is significant in aboveground reservoirs.

Proposed ASRs in previous modeling showed an accumulation of storage at the end of the simulation period. This untapped source of water was exploited by diverting ASR water in more remote areas. For example, the operation of ASRs in LECSA 1 was modified so that it is now possible to divert this water back into the WCAs in times of excess, making it available to other users of the regional water.

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